DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]In the pattern which has the basic pattern in which this invention is repeated in a predetermined pitch, About the pattern comparison-checking method and device which compare basic pattern and inspect the existence of a defect, etc., It is related with the visual inspection method and device which compare nearby cell patterns one by one, and inspect a pattern, a pattern of a photo mask, etc. which were formed on semiconductor wafers, such as semiconductor memory by which especially a cell pattern is repeated.
[0002]
[Description of the Prior Art]Picturizing the formed pattern, generating image data, analyzing image data, and inspecting the existence of the defect of a pattern, etc. is conducted widely. In particular, in the field of semiconductor manufacture, the visual inspection apparatus which inspects the pattern formed on the photomask inspection device which inspects a photo mask, or the semiconductor wafer is used widely. If this invention is a pattern in which basic pattern, such as a photo mask and a wafer top pattern, is repeated, it is applicable to the inspection of any patterns, but it explains in the following explanation by making into an example the image data which obtained the pattern formed on the wafer by picturizing it optically.
[0003]Drawing 1 shows signs that the semiconductor chip 101 was formed on the semiconductor wafer 100. Generally, since such a semiconductor chip 101 is called a die, this word is used also here. The manufacturing process of a semiconductor device will take a long time, by the time it ends all the processes, since the pattern of many layers is formed on the wafer 100, and if there is a defect with at least one serious layer, the die will become poor and the yield will fall. Then, the image data which picturized and obtained the pattern formed at the intermediate process is analyzed, the layer which produced the serious defect is removed and forming again, or feeding back defective information to a manufacturing process and improving

the yield is performed. For this reason, a visual inspection apparatus (inspection machine) is used.

[0004]Drawing 2 is a figure showing the outline composition of a visual inspection apparatus. As shown in drawing 2, the wafer 100 is held on the stage 11. It converges with the condensing lens 15, and after being reflected by the half mirror 13, the illumination light from the light source 14 passes the object lens 12, and illuminates the surface of the wafer 100. The optical image of the surface of the illuminated wafer 100 is projected on the imaging device 16 with the object lens 12. The imaging device 16 changes an optical image into the picture signal which is an electrical signal. A picture signal is digitized, is changed into image data, and is memorized by the image memory 17. The image processing portion 18 processes the image data memorized by the image memory 17, and investigates the existence of a defect, etc. The control section 19 controls each part of a device, such as the stage 11, the image memory 17, and the image processing portion 18.

[0005]A high resolution with the dramatically detailed pattern of a semiconductor device and an extraordinary visual inspection apparatus is required. Then, the one-dimensional image sensor was used as an imaging device, the stage 11 was moved in the one direction (scan), and image data has been obtained by sampling the output of an imaging device synchronizing with a scan. After the width H on the wafer which can be picturized scans the same portion of each die sequentially as it shows, for example in drawing 1, in being smaller than the width of the die 101, and a scan is completed about all the dies, another portion of each die was scanned sequentially and the image data of all the portions of each die has been obtained. Since comparison with the image data of the corresponding point of other dies obtained by the pre-scan can be performed simultaneously, a throughput improves, at the same time this scans and it obtains image data. However, the method of the scan is proposed [various] not only in this.

[0006]Drawing 3 is a figure explaining the operation which compares image data between adjoining dies. It is assumed that it is arranged as the die A, B, and C and D show drawing 3. Image data is expressed with 101 units of pixels. The array pitch in the wafer surface of a pixel is the value which multiplied the array pitch of the pixel of an imaging device by the reciprocal of photographing magnification about the direction vertical to a scan.

If it is a one-dimensional image sensor, a scanning direction is the value which multiplied by the scan speed and the sampling period.

Like a graphic display, in comparing among the dies B and C, it compares the image data (picture element data) of the pixel to which the dies B and C correspond. For example, the picture element data of the 1st row of a line of the dies B and C is compared. Therefore, the position of each pixel of the dies B and C needs to correspond. After a pattern is formed and each die exposes one die by exposing one common photo mask, it is exposed one by one by

condition of moving a wafer and exposing the following die. Therefore, the accuracy of position between dies is determined by the alignment accuracy of movement. When it is required that a gap of the portion generally compared with conducting sufficient comparison checking should be several [which is a pixel / 1/] to 1/10 or less and it cannot fill this demand only with the alignment accuracy of movement, various kinds of methods of image processing amending a gap are proposed.

[0007]As for comparison of the picture element data between dies, it is common to carry out by comparing with the picture element data of the die which generates and memorizes picture element data sequentially from the die of an end in the condition A, B, B, C and C, and D, generates the picture element data of the die generated newly immediately before, and has been memorized. By comparing in this way, the die of center portions other than the die of both ends is compared twice with two adjoining dies, if its comparison result corresponds twice, it will judge that it is normal (with no defect), and if a comparison result is not in agreement twice, it is judged to be abnormalities (those with defective). Thus, it is compared twice and the method of judging the existence of a defect by 2 times of comparison results is called a double detection. Comparison between dies is called die -**** comparison.

[0008]Semiconductor memory has the composition which repeated the basic unit called a cell, and has the composition whose pattern for it also repeated the basic pattern corresponding to a cell. Drawing 4 is a figure explaining a cell and the cell area 120 shown like a graphic display by length [of a scanning direction] (array pitch) R and the width S of a direction vertical to a scan is arranged at the 2-way repeatedly. When such a cell inspects the pattern arranged with a predetermined pitch, judging the existence of a defect is performed by comparing the picture element data of a portion corresponding between nearby cells, without performing the above die -**** comparison. This is called cell -**** comparison.

[0009]As shown in drawing 4, when a picture element pitch is [R] an integral multiple of P in P, each pixel of each cell area 120 can be measured as it is, if the position on a pattern is the same as each pixel of other cell areas. It compares one by one between the cells which adjoin like [cell -**** comparison] the case of die -**** comparison while shifting one cell at a time. Therefore, the double detection compared twice with the cell in which the cell of the center portion except the cell of both ends adjoins both sides will be performed.

[0010]

[Problem(s) to be Solved by the Invention]However, array-pitch R of a cell does not necessarily become an integral multiple of picture element pitch P actually. Drawing 5 is a figure showing the situation in that case, and R and P presuppose that it has the following relations.

R=(K+N/M) PK, M, and N are integers, it is 0<N<M and M and N assume that the maximum reduction of a fraction to the lowest terms is carried out.

[0011]in this case -- the pattern of each cell receives a pixel -- every [NP/M] -- it will shift

gradually. Therefore, picture element data cannot be compared as it is. Let P/L be a decomposition pitch noting that the gap on the pattern permitted is specified, you will call this a decomposition pitch and you approve here to a gap of 1/L of picture element pitch P (L is an integer), when comparing. Therefore, it is M<=L.

[0012]When array-pitch R is not an integral multiple of picture element pitch P, it cannot compare between the adjoining cells. Then, although changing photographing magnification in such a case, or changing a scan speed and a sampling period into it so that array-pitch R may become an integral multiple of picture element pitch P is proposed, In order for cost to increase since the hardware which changes such conditions possible is required, or to change conditions, the problem that a throughput falls is produced.

[0013]It was made in order that this invention might solve such a problem, and it aims at enabling cell -**** comparison by software, without being accompanied by change of hardware, even when array-pitch R of a cell is not an integral multiple of picture element pitch P.

[0014]

[Means for Solving the Problem]Drawing 6 is a figure explaining a principle of this invention. As mentioned above, when it is presupposed that picture element pitch P and array-pitch R have a relation of R=(K+N/M) P (however, K, M, and N are integers and) In 0 <=N<M, the maximum reduction of a fraction to the lowest terms is carried out, and M and N are M<=L (decomposition pitch). It can be considered that a pixel of a cell (cell left M pieces) which increased array-pitch R M times and which distance left, i.e., a pixel MR=(MK+N) P left, is the same position on a pattern. Therefore, what is necessary is just to measure these pixels.

[0015]Namely, a pattern comparison-checking method of this invention, Based on picture element data of a pattern which has two or more basic pattern repeated in a predetermined pitch, It is the pattern comparison-checking method inspected by comparing picture element data in which said basic pattern corresponds one by one, When expressed with resolution more than a predetermined decomposition pitch smaller than a picture element pitch, Length which carried out 1st integer (M) double [of said predetermined pitch] sets up said 1st integer (M) it can be considered that is an integral multiple of said picture element pitch, and compares picture element data in which said basic pattern as for which the 1st integer (M) individual separated corresponds one by one.

[0016]The above-mentioned formula is using decomposition pitch P/L, and has a round-off error. However, since comparison is performed between pixels MR=(MK+N) P Left, shifting a group of a pixel of a comparison object one by one, an error does not accumulate. Since comparison of picture element data is performed one by one while basic pattern shifts 1 pixel in accordance with a direction repeated, It is compared by double detection method compared with two picture element data which carried out 1st integer (M) double [of the predetermined pitch] to both sides, and as for which length separated in a center portion except a range

which carried out 1st integer (M) double [of the predetermined pitch of both sides of the picture element data of one row of a direction in which basic pattern is repeated].
[0017]In that case, although comparison will be performed once about picture element data of a range (both-ends portion) which carried out 1st integer (M) double [of the predetermined pitch of both sides except a center portion], if at least one comparison in particular is satisfactory, it will not matter. When picture element data of a both-ends portion also needs to perform two comparison, it compares with further two or more picture element data [one] of others which length left of length (MR=(MK+N) P) which carried out 1st integer (M) double [of the further predetermined pitch] which carried out the integral multiple. In this case, when accumulation with error is taken into consideration, it is desirable to consider it as a pixel left 2 MR.
[0018]As an option which performs two comparison, picture element data of a both-ends portion, resolution of the 2nd bigger decomposition pitch than a predetermined decomposition pitch -- a table -- length which sometimes carried out 2nd integer (T) double [of the predetermined pitch] sets up the 2nd integer (T) it can be considered that is an integral multiple of a picture element pitch, and the bottom compares with picture element data which carried out 2nd integer (T) double [of the predetermined pitch] and as for which length separated one by one.
[0019]Picture element data of a both-ends portion is compared with picture element data of a center portion inspected by a double detection method by the 1st comparison, What is necessary is to perform comparison 2nd after the above-mentioned peripheral part, only when not in agreement by the 1st comparison since it will be judged that there is no defect if a comparison result with picture element data of a center section judged as there being no defect is in agreement.
[0020]
[Embodiment of the Invention]Although the example in the case of inspecting hereafter the pattern formed on the semiconductor wafer in this invention is described, the outline composition of test equipment presupposes that it is the same as that of drawing 2, and picture element data is obtained by scan using a one-dimensional image sensor. The pattern formed on the semiconductor wafer presupposes that a cell is a pattern of the semiconductor memory which has a cell part by which an iterative array is carried out with a predetermined pitch.
[0021]Drawing 7 shows the arrangement of the picture element data of the cell part in the die in an example. Since it is not considered as an object in this example other than a cell part, die -**** comparison etc. are performed about other portions. When the array pitch of the pixel of a scanning direction (transverse direction) is set to P, array-pitch R of a cell is R=(K+N/M) P as shown in drawing 6, and presupposes that it is as the above-mentioned explanation about K, M, R, and L (not shown). Here, based on a design data or image pick-up conditions, an

operator sets array-pitch R as the image processing portion 18 of a figure, or the image processing portion 18 computes it automatically by image processing, or combining them, it is semiautomatic and is computed.
[0022]For explanation, as shown in drawing 7, here the picture element data of the length range of the first MR among the picture element data of a cell part A group, Make the picture element data of B group and the length range of the next MR into C group for the picture element data of the length range of the next MR, and let the picture element data of Z group and the length range of MR before that be Y group for the picture element data of the length range of the last MR. M cells are contained in each class.
[0023]The image processing portion 18 compares the picture element data 110 of the head of A group with the picture element data of the head of B group, and it compares one by one, shifting one picture element position at a time on right-hand side next. It is similarly compared with length gap ************ of MR in a transverse direction about the picture element data arranged in the direction (lengthwise direction) vertical to a scan at this time. Therefore, the picture element data of the head of the Mth cell of A group is compared with the picture element data of the head of the Mth cell of B group. In this case, since it is separated only from MR=(MK+N) P of two pixels measured, they are located in the same portion of the pattern of a cell. Therefore, what is necessary is just to compare picture element data as it is. When a comparison result is not in agreement, a possibility that either has a defect is high.
[0024]After advancing the above-mentioned comparison further and completing comparison of all the picture element data of A group and B group, the picture element data of the head of B group and the picture element data of the head of C group are compared one by one as compared with the next, shifting one picture element position at a time on right-hand side next. And an end of comparison of all the picture element data of Y group and Z group will terminate comparison of this cell part. Therefore, the double detection compared twice with the picture element data which is MR by which all the picture element data of B group to Y group adjoins both sides, and as for which length separated is performed. On the other hand, the picture element data of A group and Z group is compared only once with the picture element data of B group and Y group. When 2 times of detection results are in agreement, it judges with it being normal (with no defect), and both the picture element data in which a double detection is performed is judged with abnormalities (those with defective), when 2 times of both detection results are inharmonious. Although the picture element data of A group and Z group is only compared once, since the rate that the picture element data of A group and Z group occupies to the whole actually is dramatically small, even if it ignores, a problem in particular is not produced.
[0025]When the picture element data of A group and Z group also needs to perform two comparison, the picture element data of A group is compared with the picture element data of

C group, for example. The picture element data of Z group is compared with the picture element data of the group in front of Y group. If it is this, since accumulation of the round-off error by decomposition pitch P/L is small, a problem in particular will not be produced. That is, the picture element data of A group and Z group is compared with the picture element data which is 2MR=2(MK+N)P and as for which length separated.

[0026]Array-pitch R=(K+S/T) P is expressed with the resolution of 2nd bigger decomposition pitch P/U (U<L) than above-mentioned decomposition pitch P/L as an option which compares the picture element data of A group and Z group twice. At this time, it is S<T<=U. And it compares with the picture element data which is TR=(TK+S) P and as for which length separated about the picture element data of A group and Z group.

[0027]Only when the result of the 1st comparison processing is inharmonious, it may be made to perform processing which compares the picture element data of A group and Z group twice as mentioned above. The picture element data of A group and Z group will be compared with the picture element data of B group to Y group, and if the picture element data and the comparison result of B group to Y group which were inspected by the double detection method are in agreement, it will be because it is judged that there is no defect.

[0028]Although it was considered as M<=L in the above-mentioned explanation, it is good also as M=L. As mentioned above, although the example of this invention was described, this invention is applicable not only to the pattern formed on the semiconductor wafer but the inspection of the photo mask which is an original pattern of the pattern. Although the above-mentioned explanation explained as an example the composition which generates image data by scan using a one-dimensional image sensor, when a two-dimensional image sensor is used, for example, it is also possible to apply this invention to the comparison in which direction and both directions.

[0029]

[Effect of the Invention]According to this invention, as explained above, since cell -**** comparison can be performed by software processing even when array-pitch R of a cell is not an integral multiple of picture element pitch P, it is low cost and pattern comparison checking can be conducted in a short time.

[Translation done.]